DESIGN OF POLE LINES

Purpose: This addendum is issued to: (1) revise Table 4 to reflect the elimination of Figure 8 distribution wire in the 12-pair size, (2) revise Table 5 in accordance with PE-38, REA Specification for Figure 8 Cable, to reflect replacement of the 0.148-inch solid integral support messenger with a 3/16-inch, 7-wire strand EHS galvanized steel integral support messenger, (3) establish Table 6 to provide the information previously included for lashed cable in Table 4. Addendum No. 3 replaces Addenda Nos. 1 and 2.

TABLE 4

APPROXIMATE EQUIVALENTS OF FIGURE 8 DISTRIBUTION WIRE IN NUMBERS OF 0.109 INCH DIAMETER BARE LINE WIRES FOR USE IN CALCULATING TRANSVERSE LOADS ON POLES

FIGURE 8 DISTRIBUTION WIRE	EQUIVALENT NUMBER OF WIRES		
Pair/Support Wire	Storm Loading District		
	Heavy	Medium	Light
1/0.109" or 0.134"	2	2	4
3/0.109" or 0.134"	2	2	6
6/0.109" or 0.134"	2	2	6

TABLE 5

APPROXIMATE EQUIVALENTS OF FIGURE 8 CABLE IN NUMBERS OF 0.109 INCH DIAMETER BARE LINE WIRES FOR USE IN CALCULATING TRANSVERSE LOADS ON POLES

FIGURE 8 CABLE		EQUIVALENT NUMBER OF WIRES Storm Loading District		
Messenger	Pair/Gauge	Heavy	Medium	Light
	6/19	2	2	8
	12/19	2	4	8
3/16-Inch	18/19	2	4	10
	6/22	2	2	6
7-Wire Strand	12/22	2	2	8
	18/22	2	4	8
EHS Steel	25/22	2	4	8
	6/24	2	2	6
	12/24	2	2	6
	18/24	2	2	8
	25/24	2	4	8
	50/24	2	4	10
	25/19	2	4	10
1/4-Inch	50/19	4	4	14
	75/19	4	4	16
7-Wire Strand	50/22	2	4	10
	75/22	2	4	12
EHS Steel	100/22	4	4	14
	75/24	2	4	10
	100/24	2	4	12
	150/24	4	4	14
	200/24	4	4	16

Note: REA recommends that no poles smaller than class 9 be used for supporting Figure 8 cables having 18 pairs or less; and that no poles smaller than class 7 be used for supporting Figure 8 cables having 25 pairs or more. A margin of strength of 1.33 should be used in selecting the class pole to be used for supporting all Figure 8 cables. The relatively large number of subscribers served from cable is considered as justification for these requirements.

TABLE 6

APPROXIMATE EQUIVALENTS OF CABLE LASHED TO 6M OR 10M SUSPENSION STRAND IN NUMBERS OF 0.109 INCH DIAMETER BARE LINE WIRES FOR USE IN CALCULATING TRANSVERSE LOADS ON POLES

CABLE	EQUIVALENT NUMBER OF WIRES		
Diameter, Excluding Strand	Storm Loading District		
	Heavy	Medium	Light
0.5 inch	2	2	8
0.75 inch	2	4	12
1.0 inch	2	4	14
1.25 inch	4	4	16
1.5 inch	4	4	18
1.75 inch	4	6	20
2.0 inch	4	6	22
2.25 inch	4	6	24
2.5 inch	4	6	28

Note: Diameters stated are for cable only. However, the equivalent number of bare wires is based on the cable diameter plus the strand diameter. For example, a cable 0.5 inch in diameter lashed to a 6M or 10M strand when storm loaded equates approximately to 2 bare 0.109-inch diameter wires when these are storm loaded, in either the heavy or medium loading districts.

DESIGN OF POLE LINES

CONTENTS

1. GENERAL

1.01 This section is intended to provide REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in the design and construction of REA borrowers' telephone systems. It discusses in particular considerations in the design of pole lines for open wires, aerial distributing wires and cables.

1.02 This section is reissued to provide pole selection data in chart form instead of in tables; to provide for aerial distribution wires and for spans up to 700 feet in length.

2. BASIC CONSIDERATIONS

2.01 The basic considerations in pole line design are the determinations of pole length and pole class. This section of the manual is concerned with the proper selection of pole class on the basis of the strength requirements. The determination of pole length is controlled by ground clearances, sag, etc., which are discussed in other sections of this manual.

2.02 REA TE and CM-210, "Telephone System Design Criteria, Engineering Time Periods," specifies that the pole plant design for the area coverage design be based on the estimated demand for service in the ten-year period.

2.03 REA TE and CM-601, " Discussion of the National Electrical Safety Code" (N.E.S.C.) describes the "grades of construction" applicable to various types of outside plant construction. Grade N construction generally will be employed for construction of pole line plant on REA borrowers' telephone systems. An exception is that Grade D construction is required where communication wires (including cable) cross over railroad tracks. REA TE and CM-617, "Railroad Crossing Specifications," gives the requirements for Grade D construction at railroad crossings.

2.04 Grade N construction does not have definite requirements as to strength margins of poles employed. The N.E.S.C. states that poles for Grade N construction "shall be of such initial size and so guyed or braced, where necessary, as to withstand safely the loads to which they may be subjected, including linemen working on them."

2.05 REA recommends a margin of strength of 1.0 for subscriber lines carrying up to five pairs of wires, either open wire or aerial distribution wire and a margin of strength of 1.33 for more important lines which are: all lines carrying toll or trunk circuits; all lines carrying more than five pairs of wires either open wire or aerial distribution wire or one or more multichannel carrier systems regardless of the number of pairs of wires; and all lines supporting sheathed cable on suspension strand.

2.06 The vertical load to which poles will be subjected is the weight of the wire supports, the weight of the wires or cables which it supports, and the increased weight which must be supported when the supports and the wires or cables are coated with ice. In the design of wood pole lines, the pole class selections are based on the horizontal loads and the selected poles, in general, are assumed to be strong enough to support the vertical loads. Some exceptions are stated in certain of the following paragraphs.

2.07 The transverse load on poles is assumed to be the load applied when the wind pressure occurs at a right angle to the direction of the line. The N.E.S.C. has established definite storm loading assumptions for use in calculating the transverse loading on pole structures in three loading districts shown on a map in REA TE and CM-601. Briefly, they are:

a. Heavy Loading: Horizontal wind pressure, at a right angle to the line, of 4 pounds per square foot upon the projected* area of the cylindrical surfaces of all supported wires (including suspension strand and cables) when coated with a radial thickness of 0.5 inch of ice.

b. Medium Loading: Horizontal wind pressure, at a right angle to the line, of 4 pounds per square foot upon the projected area of supported wires (including suspension strands and cables) when coated with a radial thickness of 0.25 inch of ice.

c. Light Loading: Horizontal wind pressure, at a right angle to the line, of 9 pounds per square foot upon the projected area of all supported wires (including suspension strands and cables).

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*Projected area of a wire is a flat vertical surface having a width equal to the diameter of the bare or ice coated wire or strand and cable. Table 1 for the loading on open wires is computed in accordance with the above assumptions.

2.08 In addition to the transverse wind pressure load on the support wires and cables, the pole must also withstand the transverse load due to wind pressure on the pole itself and the attachments thereon. This additional load will vary due to differences in dimensions and length in any given pole class, and the type of attachments made on the pole. REA has adopted as an approximation for this purpose 50 pounds in the heavy and medium storm loading districts and 75 pounds in the light storm loading district, applied two feet from the pole top.

2.09 Table 1 indicates the transverse wind pressure load per foot of .109 inch diameter open wire under N. E. S. C. storm loading assumptions in the three loading districts. The variation in load for single wires other than .109 inch diameter whether bare or insulated is small enough to permit the selection of the class of pole for any type of wire commonly used in open wire telephone circuits, based on the assumption that they are all .109 inch diameter.

Table 1

Transverse Wind Loads on Open Wires Calculated in Accordance with N.E.S.C. Storm Loading Assumptions

	Storm Loading District		
Diameter of Wire, Inches	Heavy Lbs/Ft. (1/2 In. Ice)	Medium Lbs/Ft. (1/4 In. Ice)	Light Lbs/Ft. (No Ice)
.109	.370	.203	.082

2.10 The rated breaking loads applied transversely two feet from the top of poles, as established by the American Standards Association for pole classes 1 to 7, and by REA for classes 9 and 10, are given in REA TE and CM-610, "Poles." The values for a given class are the same for all species of pole timber. For classes 1 to 7, the strength of any class is 25 percent greater than the next weaker class. For example, class 6 is 25 percent stronger than class 7.

2.11 The transverse load applied to a pole by wind pressure on ice covered wires supported thereon is reduced on lines carrying more than ten wires due to the effect of "shielding." In a

group of wires placed on crossarms shielding from the wind occurs to some of the ice coated wires by other ice coated wires. The effective wind pressure on a group of wires exposed to the wind, therefore, is less than the sum of the calculated pressure on the projected areas of all of the wires. For this reason the N.E.S.C. rules state that when the number of wires on crossarms is more than ten in the heavy and medium storm loading districts, the transverse wind pressure is calculated for two-thirds of the total number of wires, but in no case less than ten wires. In the light storm loading district, the assumption is that there will be no ice and no shielding, and the transverse wind pressure is calculated on the basis of the sum of the projected areas of all supported wires. No shielding is assumed in any loading district on any other type of attachments whether suspension strands, cables, or the various types of aerial distribution wires.

2.12 Table 2 gives the actual and equivalent number of wires where shielding is involved.

Table 2

Actual and Equivalent Numbers of Wires Resulting from Wind Shielding In Heavy and Medium Loading Districts

Actual Number of Wires	Equivalent Number of Wires
2	2
4	4
6	6
8	8
10	10
12	10
14	10
16	11
18	12
20	13
22	15

2.13 The average span lengths permissible in a pole line depend on the data supplied by the wire and cable manufacturers for the various kinds and sizes of wire and cable they manufacture. The manufacturer's span length data should be consulted in determining average span lengths to be used after the kind and size of the wire or cable are selected. Other sections of this manual cover the selection of the kind and size of wire or cable required for various situations.

2.14 The "average span" selected as stated in paragraph 2.13 shall be used in the selection of the pole class for a line. This ignores the fact that all of the spans in a line may not be of this average length. Some exceptions calling for poles stronger than required by this average span are stated in certain of the following paragraphs.

2.15 Table 3 indicates the usual maximum lengths that can be purchased in the various classes of poles and kinds of timber. The usual minimum lengths of poles are as follows:

Classes 1 and 2 - 20 feet
Classes 3 and 4 - 18 feet
Smaller Classes - 16 feet

Table 3

Maximum Length of Poles
by Kinds of Timber and Classes

Timber	CLASSES 1	2	3	4	5	6	7	9	10
	Maximum Length - Feet								
Southern Pine	75	75	75	75	70	60	50	30	25
Douglas Fir	75	75	75	75	70	60	50	30	25
Lodgepole Pine	75	75	70	65	60	55	50	30	25
Jack Pine	75	75	70	65	60	55	50	30	25
Red Pine	75	75	70	65	60	55	50	30	25
Ponderosa Pine	75	75	65	65	55	55	50	30	25
Western Larch (Tamarack)	75	75	70	65	60	55	50	30	25
Western Red Cedar	75	75	75	75	55	40	40	30	25
Northern White Cedar	60	60	60	60	55	40	35	30	25

3. POLE SELECTION CHARTS

3.01 Pole Selection Charts 1 and 2 are based on the loads calculated for bare wires .109 inches in diameter, loaded in accordance with the assumptions stated in the paragraphs entitled "Basic Considerations."

3.02 Pole Selection Chart 1 is based on N.E.S.C. storm loadings for the margin of strength of 1.0 which does not involve shielding. Pole Selection Chart 2 is based on N.E.S.C. storm loadings for the margin of strength of 1.33 with the shielding allowance taken into account for more than ten wires. The "equivalent" number of wires is to be used in applying both tables. Distribution wire and cables shall be equated to actual wires, as discussed in paragraph 5 below.

3.03 The span lengths indicated for the different pole classes in Charts 1 and 2 are on the basis of pole strength alone and do not take into account limitations of span length due to wire strength, ground clearance, or other factors.

4. POLE SELECTION FOR OPEN WIRES

4.01 In using Charts 1 and 2, it is necessary to know the average span lengths that are to be used. The size and kind of wire or cable used is a major factor in determining the average spans as stated in paragraph 2.13. When the average span length is decided for the wire to be used and the number of wires for the ten-year period is also decided, the class of pole for that span length and number of wires are selected from Charts 1 or 2, depending on the type of line as per paragraph 2.05.

4.02 In certain situations it may be necessary to select stronger poles than indicated by use of Charts 1 or 2. Some of these situations are covered in the following paragraphs.

4.021 On leads employing class 10 poles for tangent construction, class 9 poles shall be used at points requiring a guy and anchor.

4.022 On leads employing class 9 poles for tangent construction, class 7 poles shall be used at points requiring a guy and anchor. On leads employing class 7 poles and larger, the same class pole may be employed for points requiring a guy and anchor.

4.023 Turning a small angle on an unguyed pole may require the use of a stronger pole than the others in the line. This situation is discussed in REA TE and CM-650, "Guys and Anchors on Wire and Cable Lines."

4.024 Where sidearm construction is employed on open wire lines the pole shall be one class stronger than the remainder of the line due to the eccentric load, except on joint pole construction where the two-pin sidearm is used.

4.025 Wire crossings over railroad tracks usually require poles of a stronger class than the remainder of the pole line. REA TE and CM-617 gives minimum railroad crossing pole classes for various wire loads, the number of wires that are allowed on crossing poles of the several classes without side guys for different span lengths, and the number of wires that are allowed on crossing poles without head guys.

4.026 On leads employing class 9 and 10 poles, it may be necessary to use poles of a stronger class to obtain ground clearance at railroad and highway crossings because of the length limitations of these two pole classes which are given in Table 3.

4.027 Other considerations may also require stronger poles than those indicated in Charts 1 and 2. One consideration of this nature is the exposure of the line to storms. A line located along a ridge or a coastal area would be more exposed to storms than a line located in a more protected area. The direction of the prevailing wind would also be a consideration. If experience in the area of the telephone system indicates that N.E.S.C. loading is frequently exceeded, it is incumbent upon the engineer to base the pole line design on local experience and construction practices and use poles stronger than required by the basic data of Charts 1 and 2.

4.03 Charts 1 and 2 show that the class 10 pole is not recommended by REA for more than six wires in any case. This recommendation is due to the consideration that if more than six wires were to be placed, a 10-pin crossarm might be used and a lineman working on the end of such a crossarm would produce a considerable eccentric load on the pole, which could result in breaking the pole with injury to the lineman. Also, with long span construction the vertical load present and the twisting effect on the pole that usually occurs in the presence of storm conditions may result in splitting of a smaller pole

where the crossarm is attached to the pole. In view of these considerations, class 10 poles should not be employed for ultimate wire loads of more than six wires nor should 10-pin crossarms be placed on such poles.

4.04 The REA Specification (PE-9) for poles requires that poles shall be framed; that is, gained, bored and roofed, in accordance with Drawing 801, "Pole Framing," which is included in the specification, unless the purchases specifically indicate otherwise by the drawing submitted with and forming a part of the order. Drawing 801 states that poles 20 feet or less in length are gained for one crossarm and longer poles are gained for two crossarms.

5. POLE SELECTION FOR CABLE

5.01 REA recommends that no poles smaller than class 7 be used for supporting cable. As stated in paragraph 2.05, a margin of strength of 1.33 is recommended for poles supporting cable. The relative importance of service in a cable due to the number of customers involved is considered as justifying these requirements.

5.02 Poles intended for use on lines that are to support only cable can have the gains and crossarm throughbolt holes omitted. This is not advisable unless a considerable number of the poles for a project are to support nothing but cable. It is necessary to bore the holes for cable support throughbolts on the job whether or not the poles are ordered framed.

5.03 The suspension strand and guying assist the poles in providing strength to sustain the longitudinal load from wind pressure, weight of cable and suspension strand or the concentrated load due to workmen on a cable platform attached in the span. Longitudinal loading is not considered in this section but is considered in guying and is discussed in REA TE & CM-650.

5.04 The computed transverse wind loads for cable on suspension strand, and for aerial distribution wires, permit translating the results into equivalent numbers of .109 inch diameter bare wires. Table 4 gives the approximate equated values to be used in pole selection.

Table 4

Approximate Equivalents of Cable on Suspension Strand and Aerial Distribution Wires in Numbers of .109 Inch Diameter Bare Wires

	Storm Loading Districts		
	Heavy	Medium	Light
1 and 2 Pr. Aerial Distribution Wire	2	2	4
4 and 6 Pr. Aerial Distribution Wire	2	2	6
12 and 18 Pr. Aerial Distribution Wire	2	2	8
Cable on 5/16 inch (6M) Strand	4	6	16
Cable on 3/8 inch (10M) Strand	6	6	22

5.05 The procedure for determining the class of poles to support a cable on suspension strand is to select the equivalent number of wires for the cable from Table 4 for the proper storm loading district. Then reference is made to Chart 2 (Margin of Strength = 1.33) to find the required class of poles for the average span length that is contemplated.

6. POLE SELECTION FOR AERIAL DISTRIBUTION WIRES

6.01 The basic considerations stated in paragraph 2.05 determine whether Pole Selection Chart 1 or Chart 2 shall be used in selecting the pole class for aerial distribution wires, the decision depending on the number of pairs in the wire makeup. Table 4 shows the sizes of aerial distribution wire presently available. For the 1, 2 and 4 pair sizes, Chart 1 shall be used unless a trunk is applied to any pair in which case Chart 2 shall be used. The pole class required is selected for the average span length contemplated and for the equivalent number of wires found in Table 4. REA TE and CM-618, "One Pair Aerial Distribution Wire" and REA TE and CM-633, "Aerial Distribution Wire, Multipair" gives permissible span length data.

6.02 As with open wire lines, certain situations may require individual poles in a line supporting only aerial distributing wire to be of a stronger class than the others in the line. See paragraph 4.02 which applies also in this problem of pole selection.

7. POLE SELECTION FOR COMBINATIONS OF OPEN WIRES AND CABLE, OR FOR OPEN WIRES AND AERIAL DISTRIBUTION WIRE

7.01 Some situations may require both open wire and cable or open wire and aerial distribution wire on the same pole. The procedure for determining the class of poles to support both the open wire and cable or open wire and aerial distribution wire is to find the sum of the "equivalent" numbers of wires for the two types of facilities that are to be supported by the poles. If the number of open wires is 10 or less the actual number is used as the "equivalent" number. For more than 10 open wires, the equivalent number is found from Table 2. The equivalent number of wires for the distribution wire or the cable is found from Table 4. The values taken from the two tables are added to give the total equivalent number of wires. The class of pole is then selected from Chart 1 or Chart 2, depending on the "basic considerations" stated in paragraph 2.05 and on the contemplated average span length and the equivalent number of wires.

8. POLE SELECTION FOR PUSH BRACES AND ANCHOR GUYED STUB POLES

8.01 A pole used as a push brace shall be the same class as the pole it braces.

8.02 A pole used as a stub for an overhead guy and an anchor guy shall be of the same class as the pole to which it is associated.

9. EXAMPLES OF POLE SELECTION

9.01 Example 1. Assume that a pole line is to support a ten-year requirement of 10 bare open wires entirely for subscriber lines in the heavy storm loading district on one 10-pin crossarm; that the average spans are to be 300 feet for which suitable wire is selected and that no carrier system is contemplated.

Reference to paragraph 2.05 indicates that under the above conditions Chart 1 should be used in the pole selection. Chart 1(H) indicates that class 7 poles can be used. If the average of any two adjacent spans exceeds 300 feet, a stronger class pole should be used.

9.02 Example 2. Assume that a pole line is to support a ten-year requirement of 10 bare open wires in the heavy storm loading district on one 10-pin crossarm, and that a 25-pair, 22-gauge plastic-insulated, plastic-sheathed cable on 6M strand is

also to be on the poles, and that the average spans are to be 300 feet.

Paragraph 2.05 indicates that the cable necessitates use of Chart 2 because a margin of strength of 1.33 is required. The 10 wires will have no shielding so will equate to 10, determined from Table 2. The 25-pair cable on 6M strand equates to 4 open wires in heavy loading, determined from Table 4. The total load on the poles will be that of the 10 plus 4 which is 14 equivalent wires.

Chart 2(H) shows the data for 13 and 15 wires but not for 14. Therefore, for the 14 wires it must be determined whether the pole class shown for 15 wires will be strong enough for 14 wires. In this case for the 300 foot spans, the class 4 pole is the correct size.

9.03 Example 3. Assume that a pole line is to support a ten-year requirement of 2 open wires for a subscriber line and one 6-pair, 19-gauge aerial distribution wire in the medium storm loading district; that the average spans are to be 400 feet and that no trunk circuits nor carrier systems are contemplated.

Table 4 indicates that the load due to the 6-pair, 19-gauge aerial distribution wire will be equivalent to that of 2 open wires. The total load will be the sum of that of the 2 open wires plus the 2 equivalent wires, a total of 4 wires.

Reference to paragraph 2.05 shows that under the above conditions Chart 2 should be used in the pole selection because more than 5 pairs of wires are to be supported. Chart 2(M) indicates that class 9 poles are required for 4 equivalent wires for the 400 foot average spans in the medium storm loading district.

9.04 Example 4. Assume that a pole line is to support a ten-year requirement of 2 open wires for a subscriber line and one 4-pair aerial distribution wire in the heavy storm loading district; that the average span lengths are to be 300 feet and that no trunk circuits nor carrier systems are contemplated.

Table 4 indicates that the load due to the 4-pair distributing wire will be equivalent to that of 2 open wires. The total load will be the sum of that of the 2 open wires plus the 2 equivalent wires, a total of 4 wires.

Reference to paragraph 2.05 shows that under the above conditions Chart 1 should be used in the pole selection because there are not more than 5 pairs of wires involved and all wires are for the subscriber lines and no carrier system is contemplated. Chart 1(H) indicates that class 9 poles are required for 4 equivalent wires for the 300 foot average spans in the heavy storm loading district.

9.05 Example 5. Assume that a pole line is to support a ten-year requirement of 20 wires for subscriber lines only, in the heavy storm loading district, that the spans are to be 300 foot average and that no carrier system is involved.

Table 2 indicates that 13 wires are the equivalent of 20 wires due to wind shielding. Reference to paragraph 2.05 shows that under the above conditions Chart 2 should be used in the pole selection because there are more than 5 pairs of wires involved. Chart 2(H) indicates that class 4 poles are required for the 13 equivalent wires for the 300 foot spans in the heavy storm loading district.

POLE SELECTION CHART BY CLASS

CHART 1

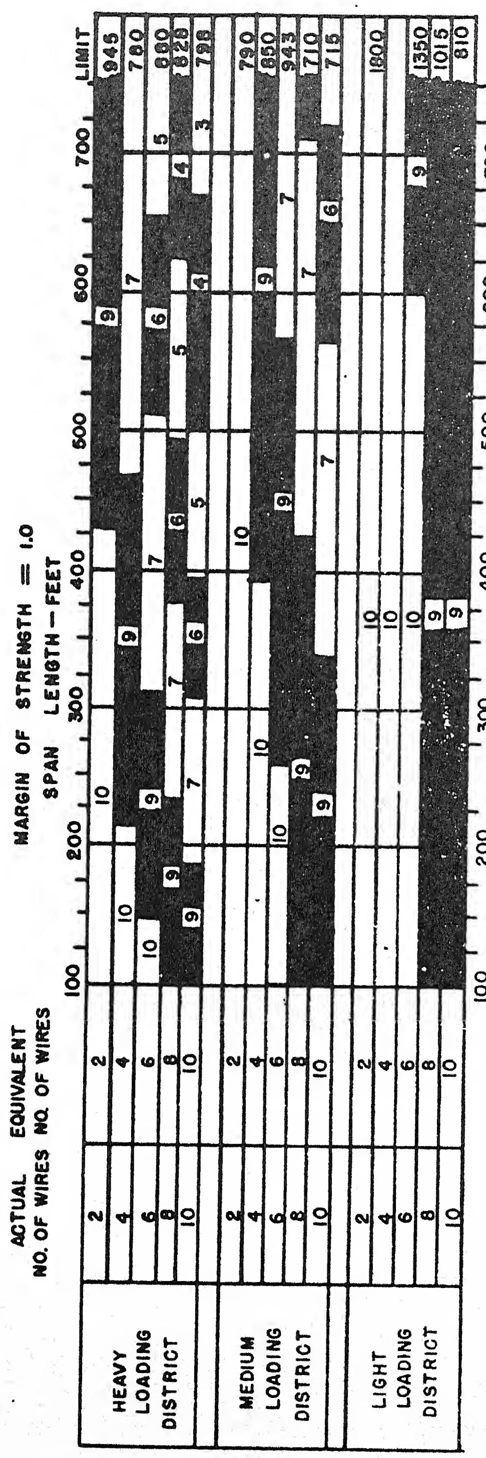
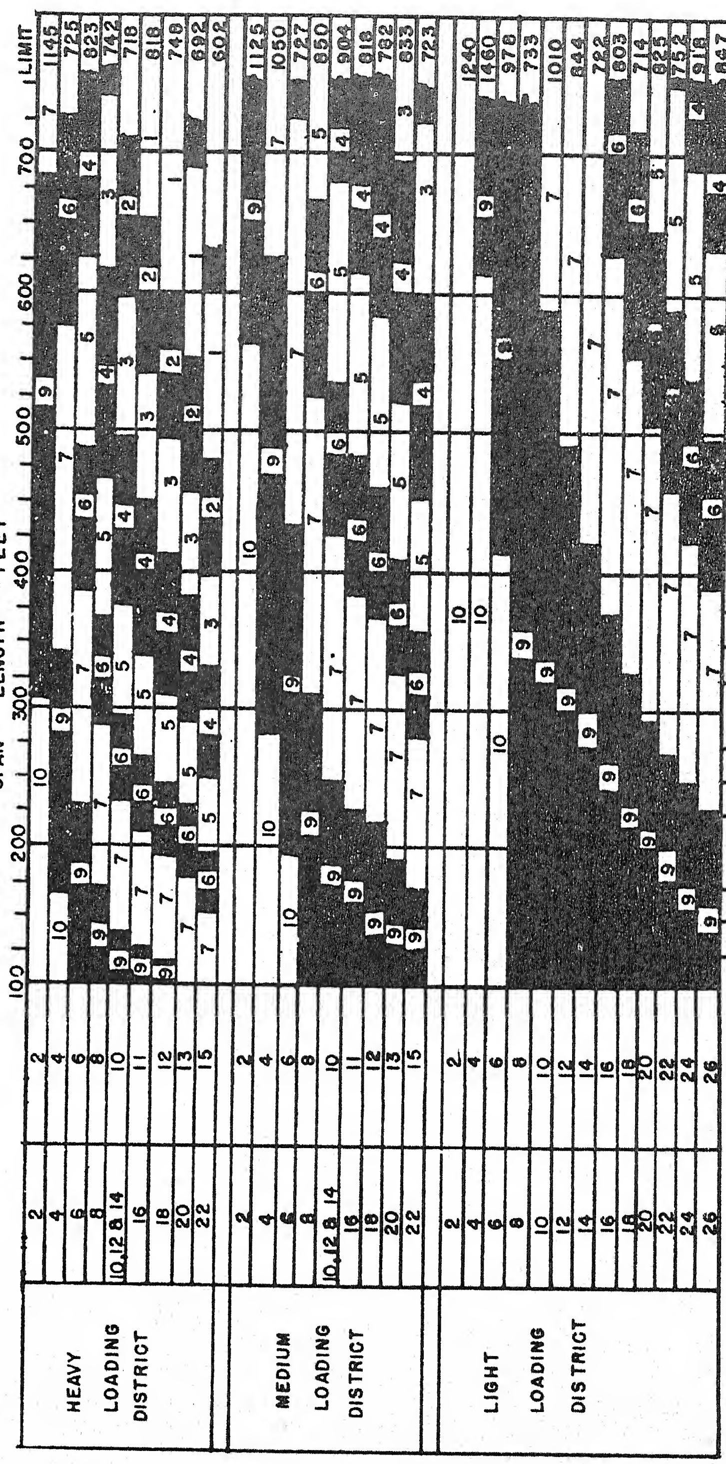


CHART 2



CHARTS 1 & 2

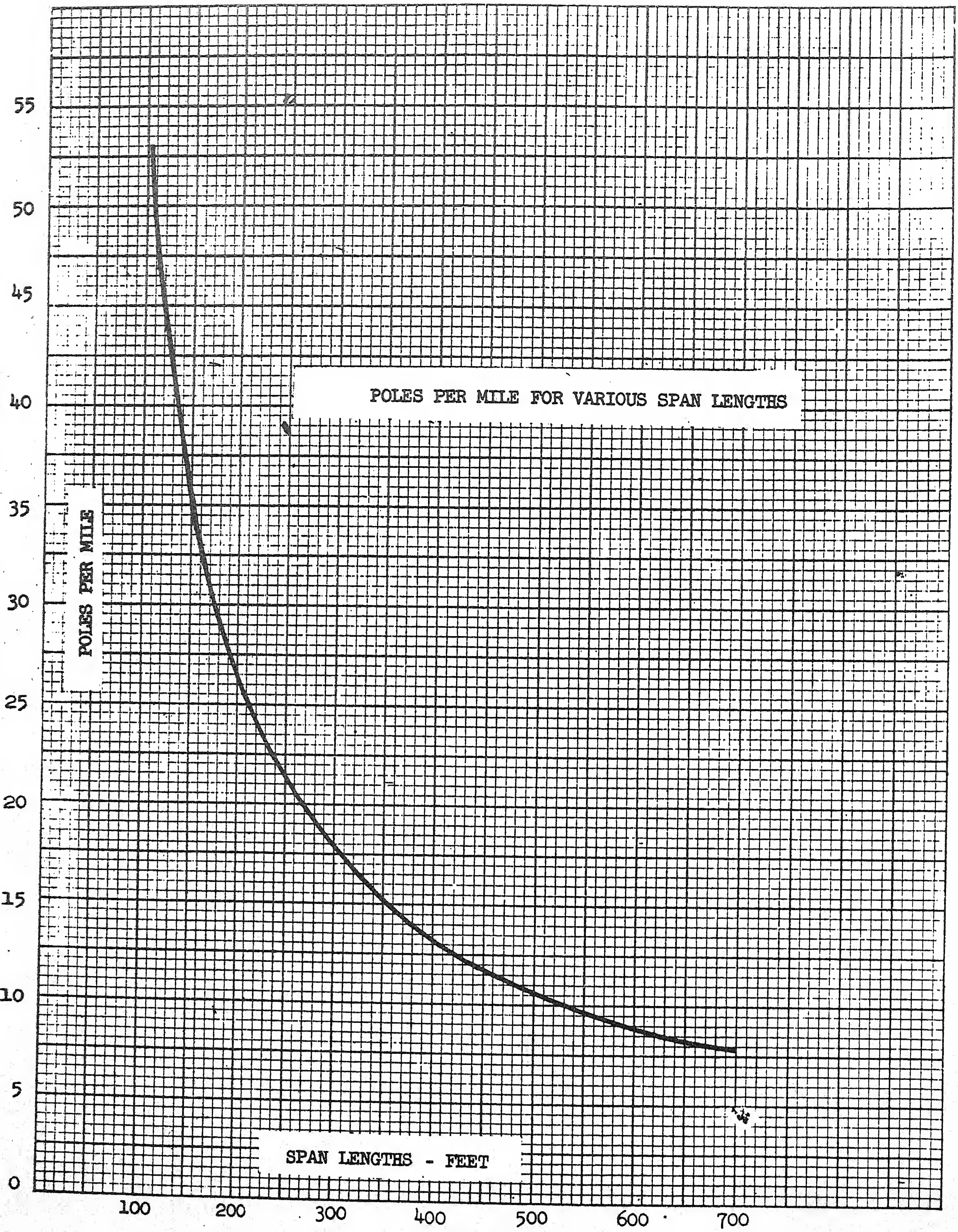

POLES PER MILE FOR VARIOUS SPAN LENGTHS
POLES PER MILE
SPAN LENGTHS - FEET
55
50
45
40
35
30
25
20
15
10
5
0
100
200
300
400
500
600
700

CHART 3